

Appendix I. Product Chemistry of Atrazine and the Structures of Atrazine and Its Major Degradates and Metabolites

Chemical/ Physical Properties of Atrazine

CAS Number: 1912-24-9

Color/ Form/Odor: Available as suspension concentrate; wettable powder; water-dispersible granules.

Molecule Weight: 215.69 g/mole

M.P.: 175.8 °C

Vapor Pressure: 2.89×10^{-7} mm Hg at 25 °C

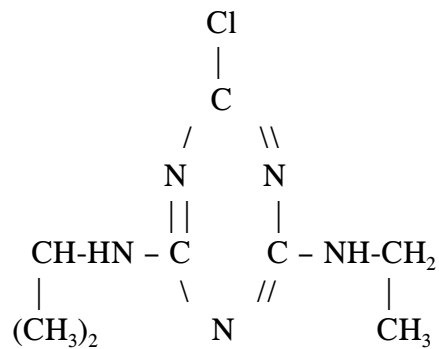
Density/Spec. Gravity.: 1.23 g/mL at 22 °C

Octanol/Water Partition (Kow): Log Kow = 2.68 22 °C

Solubility: 0.033 g/L of water at 22 °C

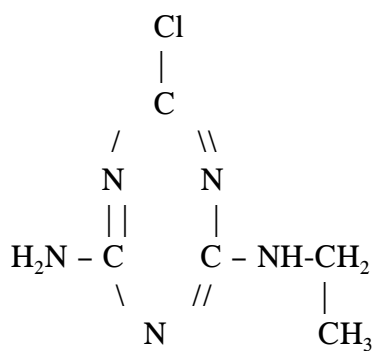
Odor/Taste Thresholds: N/A

Henry's Law Constant: 2.48×10^{-9} atm-m³/mole (calculated)

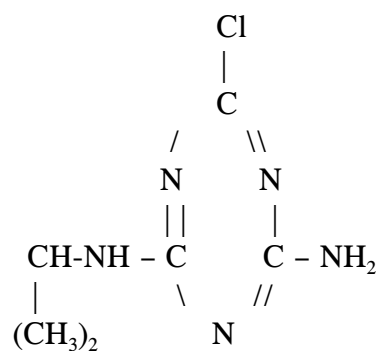


Atrazine

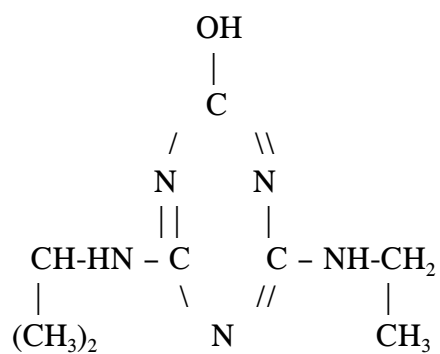
Atrazine Soil Degradates:



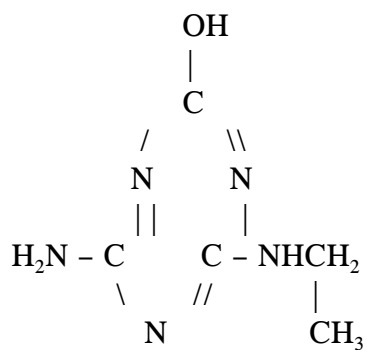
Deisopropylatrazine
(G-28279)



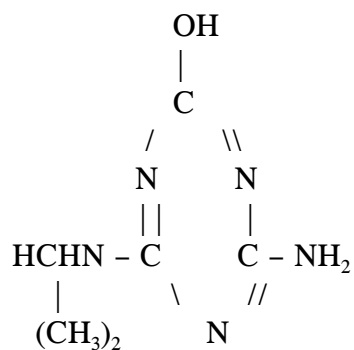
Deethylatrazine
(G-30033)



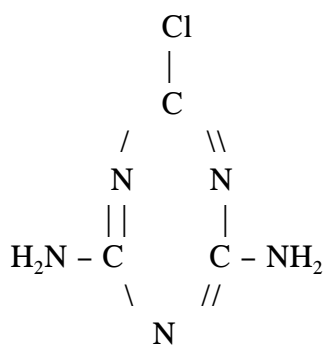
Hydroxyatrazine
(G-34048)



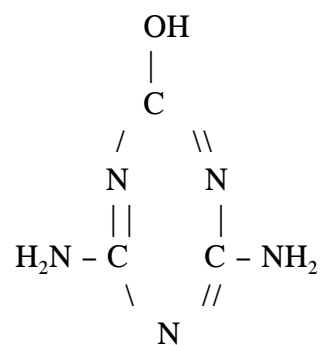
Deisopropylhydroxyatrazine
(GS-17792)



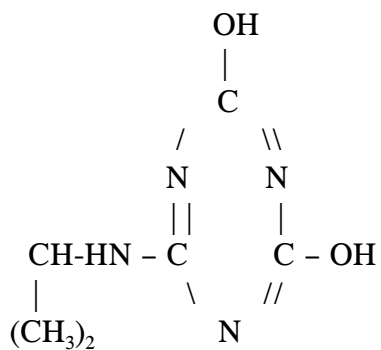
Deethylhydroxyatrazine
(GS-17794)



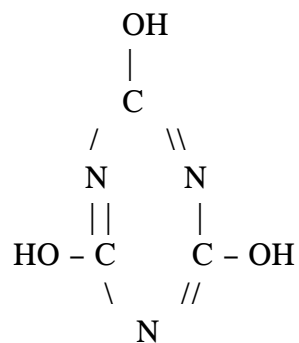
Diaminochlorotriazine
(G-28273)



Diaminohydroxyatrazine
(G-17791)

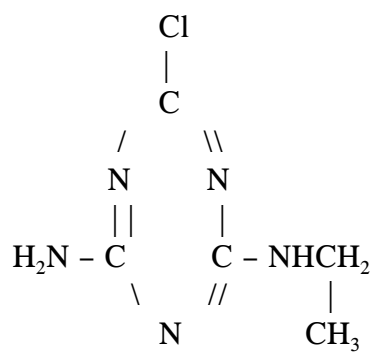


2, 4-Hydroxy-6-isopropylamino-s-triazine
(G-11957)

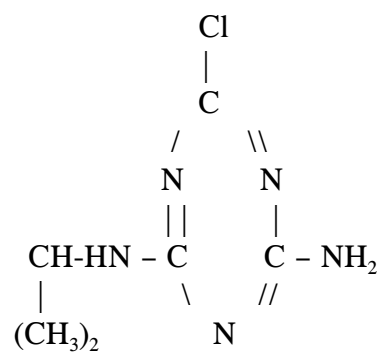


Cyanuric Acid

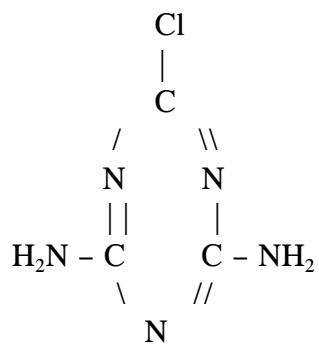
Atrazine Photodegradates (Burkhard and Guth, 1976):



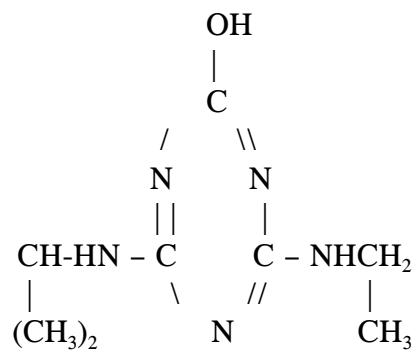
Deisopropylatrazine
(G-28279)



Deethylatrazine
(G-30033)

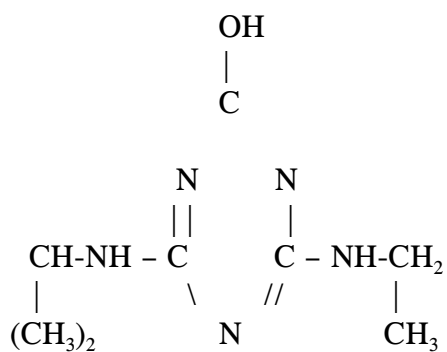


Diaminochlorotriazine
(G-28273)

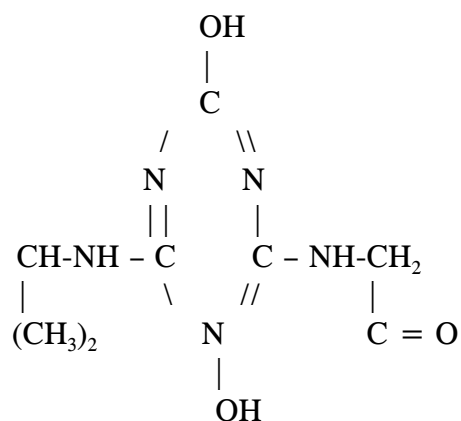


Hydroxyatrazine
(G-34048)

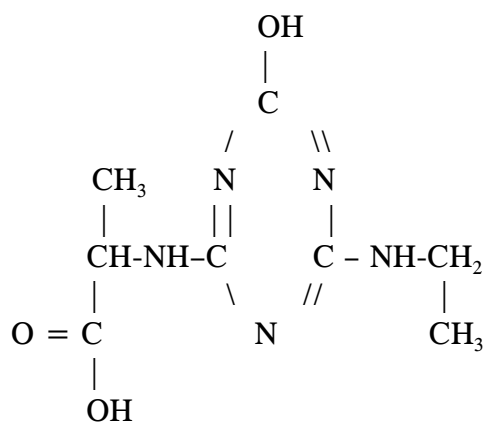
Major Mammalian Metabolites:



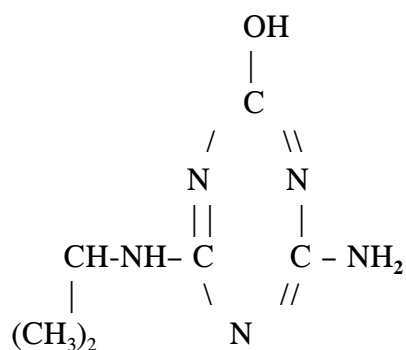
Hydroxyatrazine
(G-34048)



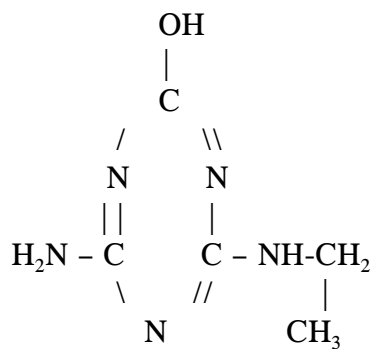
Ethanoichydroxyatrazine



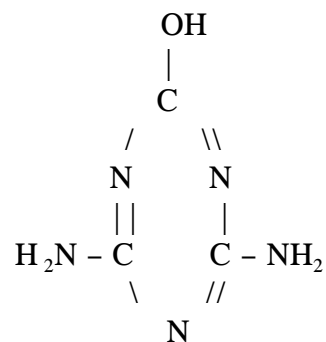
Isopropanoichydroxytriazine



Deethylhydroxyatrazine
(GS-17794)

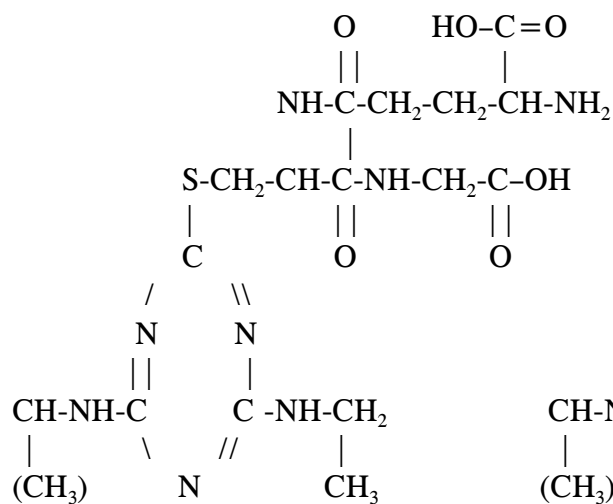


Deisopropylhydroxyatrazine
(GS-17792)

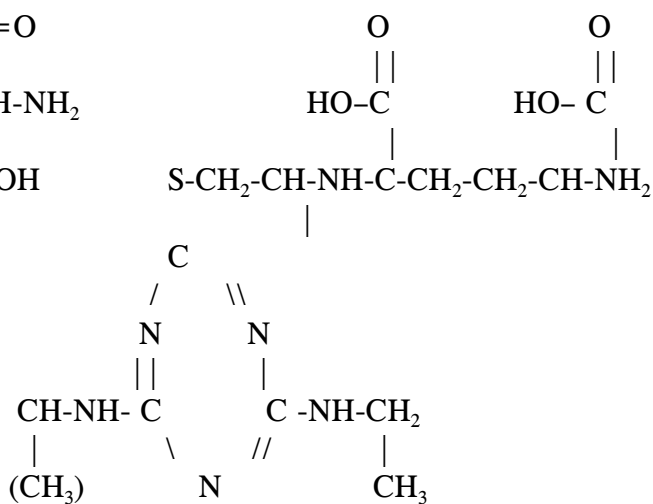


Diaminohydroxyatrazine
(GS-17791)

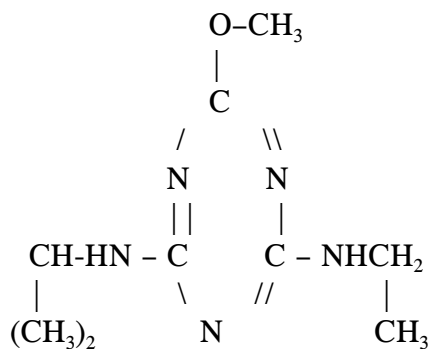
Major Plant Metabolites:



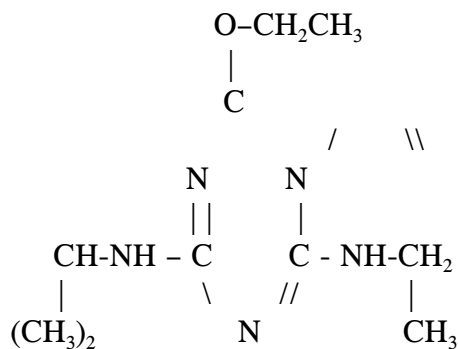
S-(4-Ethylamino-6-isopropylamino-2s-triazino) Glutathione



L-Glutamyl-S-(4-ethylamino-6-isopropylamino-2-s-triazino)-L-Cysteine



2-Methoxy-4-ethylamino-6-isopropylamino-s-triazine



2-Ethoxy-4-ethylamino-6-isopropylamino-s-triazine

Appendix II. Summary of Guideline Environmental Fate Studies

Each individual guideline study is discussed separately. The product chemistry and chemical structures of atrazine and its degradation products are listed in Appendix I.

Hydrolysis (161-1)

Based on the results of the hydrolysis study (MRID 40431319), atrazine did not hydrolyze at pH 5, 7, and 9. It was concluded that hydrolysis is not an important degradation mechanism for atrazine.

Aquatic Photodegradation (161-2)

The study (MRID 00024328) showed that [¹⁴C]atrazine degraded with a registrant-calculated half-life of 25 ± 2 hours in unbuffered aqueous solutions (initial pH 6.8) that were irradiated with a 125-W mercury vapor lamp at 15°C; in unbuffered aqueous solutions sensitized with 1% acetone, the half-life decreased to 4.9 ± 0.5 hours.

The study (MRID 42089904) showed that in buffered solution at pH 7, atrazine did not appreciably degrade under natural sunlight conditions with a calculated half-life of approximately 335 days from a rate constant of 1.72×10^{-4} hours⁻¹. However, under artificial light irradiation with mercury arc lamp, atrazine degraded at a faster rate with a half-life of approximately 17 hours. Due to the lack of a comparison of the mercury arc lamp with natural sunlight, and no UV-VIS spectrum of atrazine in pH 7, the study is considered to be supplemental. For the purpose of risk assessment, the half-life result of 335 days with natural sunlight should be considered. Information is requested on the intensity of the mercury arc lamp and the US-VIS spectrum of atrazine in pH 7 for more accurate review.

Soil Photodegradation (161-3)

The study (MRID 40431320) was investigated with both natural and artificial sunlight exposures. The results with artificial sunlight showed a half-life of 5.3 days, when corrected with dark control, the half-life was 7.4 days. With natural sunlight, the half-life was determined to be 12 days.

The study (MRID 42089905) was investigated with artificial sunlight exposure. The half-life under non-irradiated conditions was 267 days, and the half-life under irradiated conditions was 38 days. The net half-life attributable to photodegradation is 45 days.

Aerobic Soil Metabolism (162-1)

The interim study (MRID 40431321) was considered supplemental. Based on the data of 94 days, the half-life of atrazine in loam soil was calculated as 140 days. The main metabolites detected at all sampling times were G-30033 and G-28279, but the metabolite G-34048 was not detected until days 62 and 94. The completed study (MRIDs 40629303, 42089906) was also

considered supplemental. The calculated half-life was 146 days under non-sterile aerobic conditions and to be very slow under sterile conditions. The degradates identified were G-30033, G-28279, G-28273, G-34048, GS-17794, and GS-17792.

The second study (MRID 00040663) with four Hawaiian soils was rejected due to several deficiencies: (1) no material balances, (2) soils were not completely characterized, (3) pattern formation and decline of degradates was not addressed, and (4) purity of the test substance was not reported.

For the similar deficiencies as the second study, the third study (MRID 40431322) with a wet Tennessee soil was also rejected.

Anaerobic Soil Metabolism (162-2)

The study (MRID 40431321) was considered supplemental. The calculated half-life for atrazine under anaerobic conditions was about 159 days. The metabolites G-30033 and G-28279 were present at all sampling times in both soil extracts and supernatant water; G-28273 and G-34048 were also present, but not at all sampling times.

The half-life value was not established in the second study (MRID 40629303). The degradates identified were G-30033, G-28279, G-28273, and G-34048.

The study (MRID 42089906) with atrazine applied on California loam soil showed that when flooded with water, atrazine degraded with a calculated half-life of approximately 159 days. The degradates identified were G-30033, G-28279, G-28273, and G-34048.

Anaerobic Aquatic Metabolism (162-3)

The study (MRID 40431323) is acceptable. The combined water/sediment (sandy clay) half-life was calculated as 608 days (330 days in sediment; 578 days in water). Production of volatile materials was minimal. Bound residues increased with time, but leveled to about 10% of applied dose by month 12. About 70% of radioactivity in water and 4% in sediment was still associated with parent atrazine after 12 months. Metabolites were present at low levels (G-30033, 4.7%; G-34048, 5%; and G-28279, 1.4%).

Mobility/Adsorption/Desorption (163-1)

Several studies (MRID 00027134, 00116620, 00044017, 00098254, and 00105942) were unacceptable due to various deficiencies. The study (MRID 40431324) was acceptable and partially contributed to fulfill data requirements for the mobility of atrazine. A batch-equilibrium adsorption/desorption was conducted with four different soils and four different concentrations of ¹⁴C-label atrazine. The K_{ads} constants ranged from 0.427 (sand) to 2.030 (loam soil). The K_{des} constants ranged from 2.261 (silty loam soil) to 14.90 (sandy loam soil). K_{oc} ranged from 55.0 (sandy loam soil) to 135 (loam soil) for the adsorption phase. These results indicated that atrazine was not strongly adsorbed onto soil particles and that desorption

occurred readily.

A batch-equilibrium adsorption/desorption was conducted with four different soils and four different concentrations of ^{14}C -label G-28273 (MRID 40431327). The Kads constants ranged from 0.108 (sand) to 0.800 (silty clay loam). The Kdes constants ranged from 1.172 (silty clay loam) to 6.620 (sandy loam). Koc ranged from 11.6 (sandy loam) to 59.5 (silt loam) for the adsorption phase. These results indicated that G-28273 was not strongly adsorbed onto soil particles and that desorption occurred readily.

A batch-equilibrium adsorption/desorption was conducted with four different soils and four different concentrations of ^{14}C -label G-28279 (MRID 40431325). The Kads constants ranged from 0.225 (sand) to 1.144 (loam soil). The Kdes constants ranged from 1.784 (silty loam) to 12.479 (sand). Koc ranged from 35.1 (sandy loam) to 82.3 (silty loam) for the adsorption phase. These results indicated that G-28279 was not strongly adsorbed onto soil particles and that desorption occurred readily.

A batch-equilibrium adsorption/desorption was conducted with four different soils and four different concentrations of ^{14}C -label G-30033 (MRID 40431328). The Kads constants ranged from 0.116 (sand) to 0.963 (silty clay loam). The Kdes constants ranged from 8.104 (silty clay loam) to 12.87 (silt loam). Koc ranged from 12.8 (sandy loam) to 66.5 (silty loam) for the adsorption phase. These results indicated that G-30033 was not strongly adsorbed onto soil particles and that desorption occurred readily.

A batch-equilibrium adsorption/desorption was conducted with four different soils and four different concentrations of ^{14}C -label G-34048 (MRID 40431326). The Kads constants ranged from 5.518 (sand) to 22.26 (silty clay loam). The Kdes constants ranged from 8.104 (silty clay loam) to 12.87 (silt loam). Koc ranged from 350 (sand) to 680 (silty loam) for the adsorption phase. These results indicated that G-34048 was the strongest adsorbed among the atrazine degradates.

In a series of studies (MRID 40431329 to 40431334) with soil thin-layer chromatography, only the degradate, hydroxyatrazine (G-34048), showed low mobility, others (atrazine, diaminochlorotriazine (G-28273), deisopropylatrazine (G-28279), and deethylatrazine (G-30033)) showed high mobility in the soil environment.

In a series reports (MRID 41257901, 41257902, 41257904, 41257905, and 41257906), the adsorption/desorption characteristics of atrazine, hydroxyatrazine (G-34048), diaminochlorotriazine (G-28273), deisopropylatrazine (G-28279), and deethylatrazine (G-30033) were addressed. The results are summarized in the tables below.

Sorption Coefficients of Atrazine and Its Main Degradates

Soil	Atrazine	Diaminochloro- s-triazine (G-28273)	Deisopropyl- atrazine (G-28279)	Deethyl- atrazine (G-30033)	Hydroxy- atrazine (G-34048)
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Clay	2.46 (86.9)	1.56 (55.2)	2.73 (96.8)	1.10 (36.1)	389.6 (13797)
Sand	0.20 (38.5)	0.16 (30.7)	0.16 (30.4)	0.06 (12.2)	1.98 (374.2)
Sandy Loam	0.79 (70.4)	0.65 (57.9)	0.51 (45.2)	0.36 (31.8)	6.52 (583.3)
Loam	0.73 (155.3)	0.36 (76.0)	0.27 (58.1)	0.21 (44.9)	12.11 (2572.9)

Number in parentheses refer to Koc values; $Koc = Kads \div \%O.C.$; where $\%O.C. = \% O.M. \div 1.7$

Desorption Coefficients of Atrazine and Its Main Degradates

Soil	Atrazine (G-30027)	Diaminochloro- s-triazine (G-28273)	Deisopropyl- atrazine (G-28279)	Deethyl- atrazine (G-30033)	Hydroxy- atrazine (G-34048)
Clay	9.12 (322.9)	7.80 (276.2)	12.36 (467.9)	8.14 (288.3)	515.89 (18271)
Sand	1.51 (285.5)	Value indeterminable due to limited adsorption			9.02 (1704.2)
Sandy Loam	7.27 (650.5)	8.06 (721.0)	15.28 (1366.9)	11.19 (1001.1)	14.87 (1330.4)
Loam	4.76 (1011.5)	6.87 (1459.9)	6.98 (1484.2)	3.92 (833.3)	11.28 (22397.6)

Number in parentheses refer to Koc values; $Koc = Kdes \div \%O.C.$; where $\%O.C. = \% O.M. \div 1.7$

Adsorption/Desorption Study: Soil Characteristics

Soil Type Texture	Bulk Density (g/cm ³)	Organic Matter (%)	pH	Sand %	Silt %	Clay %	CEC meq/100g
Clay	1.22	4.8	5.9	25	33	42	24.3
Sand	1.65	0.9	6.5	96	2	2	1.8
Sandy Loam	1.28	1.9	7.5	63	20	17	6.1
Loam	1.57	0.8	6.7	44	47	9	4.3

The dealkylated degradates (G-28273, G-28279, and G-30033) are more mobile than parent atrazine, but hydroxyatrazine (G-34048) is the least mobile of the degradates. Atrazine, its dealkylated degradates, and hydroxyatrazine are very mobile in the sand soil, as shown by their low (<2) adsorption coefficients (Kads) and the low adsorption Koc values (<500). In clay soil the adsorption coefficients and Koc values were higher for parent atrazine and the dealkylated degradates, but still fall below 5 and 500. However, adsorption of hydroxyatrazine was the strongest.

The results of the batch-equilibrium adsorption/desorption studies indicate that the dealkylated degradates are as likely (or even more likely) to leach to ground water as parent atrazine. However, soil characteristics must be taken into account when assessing the leaching potential in an specific region.

Terrestrial Field Dissipation (164-1)

The results of a field dissipation study with corn soil at Donaldsonville, Georgia (MRID: 42165504) predicted a half-life of 12.75 days with residues decreasing to less than 0.4 ppm on the 27-day sampling. AAtrex® Nine-O® was applied at a rate of 4.4 lb a.i./ac to a test corn plot of sandy loam soil on June 14, 1986. The residues of degradates G-34048, G-30033, and G-28279 found in the top 0-6" depth were significant lower (< 0.05 to 0.31 ppm) compared to the parent residues which ranged < 0.05 to 0.73 ppm. The leaching data for parent atrazine and metabolites at depths below 6-12" soil depth were generally below the screening level of 0.05 ppm.

The results of a field dissipation study with bare ground at Donaldsonville, Georgia (MRID 42165505) predicted a half-life of 38.52 days with residues decreasing to less than 0.5 ppm on the 451-day sampling. AAtrex® Nine-O® was applied at a rate of 18.0 lb a.i./ac to a field plot of unvegetated sandy loam soil on June 27, 1986. The residues of degradates G-34048, G-30033, and G-28279 found in the top 0-6" depth were significant lower (<0.05 to 2.16 ppm) compared to the parent residues which ranged <0.05 to 6.98 ppm. The leaching data for parent atrazine and metabolites at depths below 6-12" soil depth were generally below the screening level of 0.05 ppm.

The results of a field dissipation study with bare ground at Ripon, California (MRID 40431336, 42165506) predicted a half-life of 102.5 days. Atrazine (90% dry flowable) was applied at a nominal concentration of 18 lb ai/ac to a field plot of unvegetated sandy loam soil in July 1986. In the 0- to 6-inch depth, atrazine was 4.75 ppm (4.75 ppm total residues) immediately after treatment, decreased to 1.05 ppm (1.20 ppm total) at 90 days, and 0.67 ppm (0.94 ppm total) at 120 days, increased to 5.31 ppm (6.24 ppm total) at 180 days, then decreased to 0.50 ppm (0.63 ppm total) at 267 days and 0.20 ppm (0.26 ppm total) at 358 days post-treatment. The major degradates were G-34048, G-30033, and G-28279.

The results of a field dissipation study with bare ground at Hollandale, Minnesota (MRID 40431337, 42165507) indicated a half-life of 261 days. Atrazine (90% dry flowable) was applied at a nominal concentration of 20 lb ai/ac to a field plot of unvegetated loam soil in July 1986. In the 0- to 6-inch depth, atrazine was 4.23 ppm (5.06 ppm total residues) immediately after treatment, increased to 10.15 ppm (11.66 ppm total) at 14 days, decreased to 5.34 ppm (6.75 ppm total) at 28 days, and was 2.90 ppm (4.88 ppm total) at 360 days post-treatment. The major degradates were G-34048, G-30033, and G-28279.

The results of a field dissipation study with a corn soil at Hollandale, Minnesota (MRID 40431339, 42165508) yielded a half-life of 261 days. Atrazine (90% dry flowable) was applied at a nominal concentration of 4.4 lb ai/ac to a field plot of loam soil planted to corn in July 1986. In the 0- to 6-inch depth, atrazine was 1.20 ppm (1.37 ppm total residues) immediately after treatment, increased to 1.40 ppm (1.59 ppm total) at 2 days, ranged from 0.48 to 1.00 ppm (0.90 - 1.17 ppm total) with no discernable pattern between 7 and 290 days, and was 0.37 ppm (0.91 ppm total) at 360 days post-treatment. The major degradates were G-34048, G-30033, and G-28279.

The results of a field dissipation study with corn soil in Ripon, California (MRID 40431338, 42165509) indicated a half-life of 58 days. Atrazine (90% dry flowable), applied at a nominal concentration of 3.96 lb ai/ac to a field plot of sandy loam soil planted to corn in July 1986. In the 0- to 6-inch depth, atrazine was 1.15 ppm (1.15 ppm total residues) immediately after treatment, increased to 2.82 ppm (2.82 ppm total) at 7 days, decreased to 1.18 ppm (1.18 ppm total) at 14 days, decreased to 0.50 ppm (0.74 ppm total) at 60 days, and was 0.02 ppm (0.53 ppm total) at 358 days post-treatment. The major degradates were G-34048, G-30033, and G-28279.

Forestry Field Dissipation (164-3)

A field dissipation half-life of 87 days was estimated for exposed soil in a forestry study at Oregon City, Oregon (MRID Nos: 40431340, 42041405). Atrazine (90% G) was applied aerially at 4 lb ai/ac to 10 acres of an immature Douglas fir forest on April 4, 1985. In tree foliage samples, atrazine was 168.2 - 294.2 ppm immediately post-treatment, 76.7 - 88.0 ppm at 7 days, 6.6 - 10.5 ppm at 29 days, and 1.6 - 3.2 ppm at 88 days post-treatment. The registrant-calculated half-life for atrazine in foliage was 13 days.

In leaf litter samples, atrazine was 73.1 - 114.2 ppm immediately post-treatment, 21.8 - 27.9 ppm at 29 days, 7.2 - 8.1 ppm at 88 days, and 0.60 - 3.4 ppm at 364 days post-treatment; the registrant calculated half-life was 66 days. In soil (0- to 6-inch depth) that was not covered with leaf litter, atrazine concentration were variable with no discernible pattern, ranging from 0.075 to 4.3 ppm. G-30033 was isolated at up to 0.118 ppm. In the 6- to 12- and 12- to 18-inch soil depths, atrazine was < 0.05 to 0.432 ppm and < 0.05 to 0.110 ppm, respectively. In soil under leaf litter, atrazine concentration were variable in the 0- to 6-inch depth, ranging from 0.077 to 4.7 ppm, and were #0.088 ppm in the 6- to 12- and 12- to 18-inch depths.

Long-Term Terrestrial Field Dissipation (164-5)

The results of a long-term field dissipation study with corn soil at Hollandale, Minnesota, (MRID 40431339, 42089911) predicted a half-life of 402 days with an r^2 of 0.81. In the 0-6" soil samples, detectable residues of atrazine, G-30033, and G-34048 were found at 451, 510, 668, 847, 1032, 1211, and 1389 DAT (days after treatment), and detectable residues of G-28279 were found at 451, 510, 668, 847, and 1032 DAT. In the 6-12" soil samples, detectable residues of atrazine were found at 510, 668, 847, 1032, and 1211 DAT, detectable residues of G-30033 were found at 668, 847, and 1032 DAT, and detectable residues of G-34048 were found at 451, 510, 668, 847, 1032, 1211, and 1389 DAT. The 12-18" soil samples produced no detectable residues of atrazine, G-28279, G-30033, or G-34048. No detectable residues of atrazine, G-28279, or G-30033 were found in the 18-24" soil samples; however, detectable residues of G-34048 were found at 1211 and 1389 DAT. In the 24-36" soil samples, no detectable residues of atrazine, G-28279, G-30033, or G-34048 were found.

The results of a long-term field dissipation study with bare ground at Hollandale, Minnesota, (MRID 40431337, 42089912) predicted a half-life of 261 days with an r^2 of 0.94. In the 0-6" soil samples, detectable residues of atrazine, G-30033, and G-34048 were found at 449, 498,

659, 839, 1020, 1200, and 1378 DAT, and detectable residues of G-28279 were found at 449, 498, 659, 839, and 1020 DAT. Detectable residues of atrazine and G-34048 were found in the 6-12" soil samples at 449, 498, 659, 839, 1020, and 1200 DAT, detectable residues of G-30033 were found at 449, 498, 659, 839, and 1200 DAT. In the 12-18" soil samples, detectable residues of atrazine were found at 449, 498, 659, 839, 1020, 1200, and 1378 DAT, no detectable residues of G-28279 or G-30033 were found, detectable residues of G-34048 were found at 449, 659, and 1200 DAT. In the 18-24" soil samples, detectable residues of atrazine were found at 449, 498, 659, 839, and 1020 DAT, no detectable residues of G-28279 were found, detectable residues of atrazine were found only at 1020 DAT, detectable residues of G-28279 were found at 449 and 498 DAT, detectable residues of G-30033 were only found at 498 DAT, and no detectable residues of G-34048 were found.

The results of a long-term field dissipation study with corn soil at Ripon, California, (MRID 40431338, 42089909) predicted a half-life of 102 days with an r^2 of 0.84. In the 0-6" soil samples, detectable residues of atrazine were found at 552 DAT, no detectable residues of G-30033 were found, and G-34048 were found at 460, 552, 726, 873, 1045 DAT samples. In the 6-12" soil samples, detectable residues of atrazine were found at 460 and 552 DAT, detectable residues of G-28279 and G-30033 were found only in the 460 DAT samples, and detectable residues of G-34048 were found at 460, 552, 873, and 1045 DAT soil samples. At the 12-18" soil depth, detectable residues of atrazine were found at 460 DAT only, no detectable residues of G-28279 or G-30033 were found, and detectable residues of G-34048 were found in the 460, 552, and 873 DAT soil samples. In the 18-24" soil samples, detectable residues of atrazine and G-28279 were found in 460 and 552 DAT soil samples, no detectable residues of G-30033 were found, and detectable residues of G-34048 were found in the 460 and 873 DAT soil samples. No detectable residues of G-28279 were found in the 24-36" soil samples, while detectable residues of atrazine and G-30033 were found at 460 DAT, and residues of G-34048 were found at 460, 552, and 873 DAT.

The results of a long-term field dissipation study with bare ground at Ripon, California, (MRID 40431336, 42089910) predicted a half-life of 110 days with an r^2 of 0.92. In the 0-6" soil samples, detectable residues of atrazine and G-30033 were found only at 460 DAT, and detectable residues of G-34048 were found in 460, 552, and 837 DAT samples. No detectable residues of atrazine or G-28279 were found in the 6-12" soil samples, detectable residues of G-30033 were found only at 552 DAT, and detectable residues of G-34048 were found in the 460, 552, and 873 DAT soil samples. No detectable residues of atrazine, G-28279, or G-30033 were found in the 12-18" soil samples, while detectable residues of G-34048 were found in the 460, 552, and 873 DAT soil samples. In the 18-24" soil samples, no detectable residues of atrazine, G-28279, or G-30033 were found, while detectable residues of G-34048 were found in the 460, 552, and 873 DAT soil samples. Detectable residues of atrazine, G-28279, G-30033, and G-34048 were found in the 24-36" soil samples for 460 DAT and residues of atrazine and G-34048 were also found at 873 DAT.

Bioaccumulation in Fish (165-4)

Based on an accepted study (MRID: 40431344), total [^{14}C]atrazine residues accumulated in

bluegill sunfish with maximum bioconcentration factors of 7.7x, 12x, and 15x in edible tissues (body, muscle, skin, skeleton), nonedible tissues (fins, head, internal organs), and whole fish, respectively, during 28 days of exposure to uniformly ring-labeled [¹⁴C]atrazine at 0.01 ppm in a flow-through system. After 21 days of depuration, [¹⁴C]atrazine were 0.21 ppm in edible tissues, 0.38 ppm in nonedible tissues, and 0.28 ppm in whole fish; depuration rates were 74, 76, and 78%, respectively.

Spray Drift Data Requirements (201-1, 202-1)

The guidelines require data of droplet size spectrum and drift field evaluation. No atrazine-specific spray drift studies were reviewed. The registrant, Novartis, is a member of the Spray Drift Task Force (SDTF). The SDTF has completed and submitted to the Agency a series of studies intended to characterize spray droplet drift potential due to various factors, including application methods, application equipment, meteorological conditions, crop geometry and droplet characteristics. EFED is currently evaluating these studies. After its review, the Agency will determine whether a reassessment is warranted of the potential risks from the application of atrazine to nontarget organisms.

Degradates Detected in Laboratory Studies

There are two major types of degradates for atrazine. The first type of degradates are formed via dealkylation of the amino groups, for which mono- and fully dealkylated degradates are known. The second type of degradates are formed by substitution of a chloro group by a hydroxy group in either parent or dealkylated degradates.

The following table provides a summary of atrazine degradates detected in the laboratory studies discussed above.

Degradates	Photolysis in Water	Photolysis on Soil	Aerobic Soil	Anaerobic Soil	Anaerobic Aquatic
Deethylatrazine G-30033 (DEA)	X	X	X	X	X
Deisopropylatrazine G-28279 (DIA)	X	X	X	X	X
Diaminochlorotriazine G-28273 (DACT)	X	X	X	X	
Hydroxyatrazine G-34048 (HA)		X	X	X	X
Deethylhydroxyatrazine GS-17794 (DEHA)		X	X		

Deisopropylhydroxy-
atrazine GS-17792
(DIHA)

X

X

Appendix III. Submitted Environmental Fate and Transport Studies

- Balu, K. 1989. Atrazine: Summary of surface water monitoring data for atrazine. Laboratory Study No. EIR-89001. 484 p. Unpublished study prepared and submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 41065205).
- Balu, K. 1991. Responses to the EPA review of the field dissipation study on Aatrex Nine-0 for terrestrial uses on bareground, Hollandale, Minnesota: Supplement to EPA MRID Number 40431337. Lab. Project Number: ABR-91064. 50 p. Unpublished study prepared and submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 42165507).
- Balu, K. 1991. Responses to the EPA review of the field dissipation study on Aatrex Nine-0 for terrestrial uses on bareground, Ripon, California: Supplement to EPA MRID Number 40431336. Lab. Project Number: ABR-91063. 110 p. Unpublished study prepared and submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 42165506).
- Balu, K. 1991. Responses to the EPA review of the field dissipation study on Aatrex Nine-0 for terrestrial uses on corn, Hollandale, Minnesota: Supplement to EPA MRID Number 40431339. Lab. Project Number: ABR-91066. 49 p. Unpublished study prepared and submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 42165308).
- Balu, K. 1991. Responses to the EPA review of the field dissipation study on Aatrex Nine-0 for terrestrial uses on corn, Ripon, California: Lab. Project Number: ABR-91065. 111 p. Unpublished study prepared and submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 42165509).
- Balu, K. and P. W. Holden. 1996. Ciba/State ground-water monitoring study for atrazine and its major degradation products in the United States. Final Report. Ciba Study No. 174-91. 24 p. Unpublished study prepared by Waterborne Environmental, Inc. Leesburg, VA.; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 43934414).
- Burkhard, N. and J. A. Guth. 1976. Photodegradation of atrazine, atraton and ametryne in aqueous solution with acetone as a photosensitizer. *Pesticide Science* 7(1):65-71. (Also In: Unpublished submission received July 19, 1978 under 201-403; submitted by Shell Chemical Co., Washington, D.C.; CDL:234469-C). (MRID # 00024328).
- Das, Y. 1989. Photodegradation of triazine(U)-carbon 14-atrazine on soil under artificial sunlight. Lab. Project Number: 89070. 109 p. Unpublished study prepared by Innovative Science Services, Inc.; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 42089905).
- Forbis, A. 1986. Uptake, depuration, and bioconcentration and metabolite characterization of carbon 14-atrazine by bluegill sunfish (*Lepomis macrochirus*): Laboratory Study No. 34737. 107 p. Unpublished study prepared by Analytical Bio-Chemistry Laboratories, Inc.; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 40431344).

- Froelich, L., T. Bixler, C. Peake et al. 1982. Soil adsorption/desorption characteristics of FMC 57020: M-4861. Unpublished study received Oct 1, 1982 under 279-EX-93; submitted by FMC Corp., Philadelphia, PA; CDL:248476-D. (MRID # 00116620).
- Guy, S. 1987. Field dissipation on Aatrex Nine-0 for terrestrial uses on bareground in Donalsonville, GA: Lab. Project Number: 1641-86-71-01-21E-27. 317 p. Unpublished study prepared by Landis International and Others; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 42165505).
- Guy, S. 1987. Field dissipation on Aatrex Nine-0 for terrestrial uses on corn in Donalsonville, GA: Lab. Project Number: 1641-86-71-01-06B-26. 325 p. Unpublished study prepared by Landis International and Others; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 42165504).
- Hardies, D. E. and D. Y. Studer. 1982. Soil thin-layer chromatography of PPG-1292: BRC 22593. Unpublished study received April 5, 1982 under 2F2666; submitted by PPG Industries, Inc., Barberton, Ohio; CDL:070755-J. (MRID # 00098254).
- Harris, C. I. 1967. Fate of 2-chloro-s-triazine herbicides in soil. J. Agric. Food Chem. 15(1):157-162. Also In: Unpublished submission received July 17, 1978 under 100-541; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 00027870).
- Helling, C. S. 1971. Pesticide mobility in soils. II. Applications of soil thin-layer chromatography. Soil Science Society of America Proceedings 35:737-748. Also In: Unpublished submission received May 5, 1975 under 464-323; submitted by Dow Chemical U.S.A., Midland, Mich.; CDL:221997-S. (MRID # 00044017).
- Klaine, S. 1987. Biotic and abiotic degradation of atrazine and three of its metabolites in a west Tennessee soil: Laboratory Study No. TX-431. 63 p. Unpublished study prepared by Memphis State University, Memphis, TN; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 40431322).
- Leake, C., D. Lines and K. Tiffen. 1981. The leaching of NC 21 314 in four soil types using soil TLC: METAB/81/40. Unpublished study received July 1, 1982 under 45639-EX-7; prepared by FBC Ltd., England; submitted by FBC Chemicals, Inc., Wilmington, DE; CDL:070966-E. (MRID # 00105942).
- Nelson, D. and D. Schabacker. 1991. Summary report: Soil metabolism of carbon 14-atrazine and metabolite characterization/identification: Lab. Project Number: 6015-185: ABR-91073. 321 p. Unpublished study prepared by Hazleton Labs America, Inc. (MRID # 42089906).
- Obien, S. R. and Green, R. E. 1969. Degradation of atrazine in four Hawaiian soils. Weed Science 17(4):509-514. (Also~In: Unpublished submission received July 19, 1978 under 201-403; submitted by Shell Chemical Co., Washington, D.C.; CDL:234476-C)

(MRID # 00040663).

- Parshley, Thomas J. 1990. Letter: Atrazine technical, EPA Reg. No. 100-529: Additional information on adsorption/ desorption data: Soil series names. 3 p. Submitted by Ciba-Geigy Corp., Greensboro, NC.
- Rustum, A. 1987. Aerobic, aerobic/anaerobic, and sterile soil metabolism of carbon 14-atrazine: Laboratory Study No. 6015-185. 133 p. Unpublished study prepared by Hazleton Laboratories America, Inc., Madison, WI; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 40431321).
- Rustum, A. 1988. Aerobic, aerobic/anaerobic, and sterile soil metabolism of ¹⁴C-atrazine: Study No. HLA 6015-185. 165 p. Unpublished study prepared by Hazleton Laboratories America, Inc., Madison, WI; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 40629303).
- Saxena, A. M. 1987. Determination of the mobility of soil-aged ¹⁴C-atrazine residues by thin-layer chromatography: Laboratory Study No. HLA 6015-186. Unpublished study prepared by Hazleton, Laboratories America, Inc., Madison, WI; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 40431330).
- Schabacker, D. 1991. Summary report: Aqueous photolysis of carbon 14-atrazine under natural and artificial light. Lab. Project Number: 12112 A: 12112 B. 185 p. Unpublished study prepared by Agrisearch Inc., Frederick, MD; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 42089904).
- Schofield, M. 1986. Combined field dissipation and aquatic non-target organism accumulation Studies on Aatrex Nine-O for forestry use at Oregon City, Oregon: Laboratory Study No. 32989. 135 p. Unpublished study prepared by Analytical Bio-Chemistry Laboratories, Inc., Columbia, MO; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 40431340).
- Spare, W. 1986. Determination of the hydrolysis rate constants of atrazine: Laboratory Study. No. 1236. 33 p. Unpublished study prepared by Agrisearch Inc., Frederick, MD; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 40431319)
- Spare, W. 1987. Anaerobic aquatic metabolism of atrazine: Laboratory Study No. 1231. 69 p. Unpublished study prepared by Agrisearch, Inc., Frederick, MD; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID 40431323).
- Spare, W. 1987. Photodegradation of atrazine on soil surfaces exposed to artificial and natural sunlight: Laboratory Study No.1237. 68 p. Unpublished study prepared by Agrisearch Inc., Frederick, MD; Submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 40431320).

- Spare, W. 1989. Adsorption/desorption of ^{14}C -atrazine: Agrisearch Project No. 12174. 59 p. Unpublished study prepared by Agrisearch, Inc., Frederick, MD; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 41257901).
- Spare, W. 1989. Adsorption/desorption of ^{14}C -G-28273: Agrisearch Project No. 12173. 55 p. Unpublished study prepared by Agrisearch Inc., Frederick, MD; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 41257904).
- Spare, W. 1989. Adsorption/desorption of ^{14}C -G-28279: Agrisearch Project No. 12170. 57 p. Unpublished study prepared by Agrisearch, Inc., Frederick, MD; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 41257905).
- Spare, W. 1989. Adsorption/desorption of ^{14}C -G-30033: Agrisearch Project No. 12169. 57 p. Unpublished study prepared by Agrisearch Inc., Frederick, MD; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 41257906).
- Spare, W. 1989. Adsorption/desorption of ^{14}C -G-34048: Agrisearch Project No. 12171. 57 p. Unpublished study prepared by Agrisearch, Inc., Frederick, MD; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 41257902).
- Speth, Robert M. 1991. Responses to the EPA review of the atrazine forestry field dissipation study at Oregon City, Oregon. Supplement to MRID 40431340). Laboratory Project ID: ABR-91067. 45 p. Unpublished study prepared by Ciba-Geigy Corp., Greensboro, NC.; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 420414050).
- Talbert, R. E. and O. H. Fletchall. 1965. The adsorption of some s-triazines in soils. Weeds 13:46-52. (Also In: Unpublished submission received July 19, 1978 under 201-403; submitted by Shell Chemical Co., Washington, D.C.; CDL:234472-J). (MRID # 00027134).
- White, S. 1987. Field dissipation study on Aatrex Nine-O for terrestrial uses on bareground, Hollandale, Minnesota: Laboratory Study No. 1641-86-71-01-21E-25. 356 p. Unpublished study prepared by Minnesota Valley Testing Labs, Inc., New Elm, MN; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 40431337).
- White, S. 1987. Field dissipation study on Aatrex Nine-O for terrestrial uses on bareground, Ripon, California: Laboratory Study No. 1641-86-71-01-21E-23. 300 p. Unpublished study prepared by Minnesota Valley Testing Labs, Inc., New Elm, MN; Submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 40431336).
- White, S. 1987. Field dissipation study on Aatrex Nine-O for terrestrial uses on corn, Hollandale, Minnesota: Laboratory Study No. 1641-86-71-01-06B-24. 372 p. Unpublished study prepared by Minnesota Valley Testing Labs, Inc., New Elm, MN; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 40431339).

- White, S. 1987. Field dissipation study on Aatrex Nine-O for terrestrial uses on corn, Ripon, California: Laboratory Study No.1641-86-71-01-06B-22. 311 p. Unpublished study prepared by Minnesota Valley Testing Labs, Inc., New Elm, MN; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 40431338).
- Yu, W. C. 1986. Determination of adsorption/desorption constants of atrazine: Laboratory Study No. 59-1A. 33 p. Unpublished study prepared by Cambridge Analytical Associates, Inc., Boston, MA; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 40431324).
- Yu, W. C. 1986. Determination of adsorption/desorption constants of G-28273: Laboratory Study No. 59-5A. Unpublished study prepared by Cambridge Analytical Associates, Inc., Boston, MA; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 40431327).
- Yu, W. C. 1986. Determination of adsorption/desorption constants of G-28279: Laboratory Study No. 59-6A. Unpublished study prepared by Cambridge Analytical Associates, Inc., Boston, MA; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 40431325).
- Yu, W. C. 1986. Determination of adsorption/desorption constants of G-30033: Laboratory Study No. 59-6A. Unpublished study prepared by Cambridge Analytical Associates, Inc., Boston, MA; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 40431328).
- Yu, W. C. 1986. Determination of adsorption/desorption constants of G-34048: Laboratory Study No. 59-7A. Unpublished study prepared by Cambridge Analytical Associates, Inc., Boston, MA; submitted by Ciba-Geigy Corp., Greensboro, NC. (MRID # 40431326).

Appendix IV. Drinking Water Characterization

The drinking water characterization is being reported in a separate report, entitled “Drinking Water Exposure Assessment for Atrazine and Various Chloro-triazine and Hydroxy-triazine Degradates.” The conclusions and summary of results (Chapter 10) are excerpted below.

10. Conclusions and Summary of Results

10.1) Atrazine concentrations in the PLEX and comparison to Office of Drinking Water MCL and short term HALs for atrazine

Of the 21,241 ground, surface, and blend water source CWSs in 21 states with atrazine data in the PLEX database through 1998, 2,386 CWSs (11.2%) had one or more atrazine detections above limits of quantification (LOQs) (Table 4-2 which is Table 4.2-3 of MRID 450587-04). Of a total of 88,766 samples in the database, 8,685 (9.8%) had detections above the LOQs (Table 4-2). The LOQs varied from 0.01 to 0.5 ug/L, but were typically at 0.1 ug/L (Table 4-3 which is Table 3.2-6 of MRID 450587-04).

The population and % of the assessed population exposed to 1998, 1997, 1996, 1995, 1994, and 1993 annual mean atrazine concentrations ≥ 3 ug/L were 16,000 people (0.02%), 129,000 people (0.18%), 156,000 people (0.19%), 506,000 people (0.79%), 331,000 people (0.58%), and 76,500 people (0.17%), respectively. The assessed populations for 1998, 1997, 1996, 1995, 1994, and 1993 were approximately 79.9, 71.6, 82.3, 64.0, 57.1, and 45.0 million, respectively.

The # of CWSs and % of the assessed CWSs with 1998, 1997, 1996, 1995, 1994, and 1993 annual mean atrazine concentrations ≥ 3 ug/L were 4 CWSs (0.05%), 26 CWSs (0.31%), 73 CWSs (0.92%), 11 CWSs (0.14%), 95 CWSs (1.49%), and 19 CWSs (0.49%), respectively. The # of assessed CWSs in those years were 8548, 8300, 7944, 7909, 6395, and 3913 CWSs, respectively.

Of the 21,241 CWSs with atrazine data in the PLEX database, 182 CWSs had one or more annual mean atrazine concentrations \geq the MCL of 3 ug/L during the 1993-1998 period (Tables 4-1 and 4-2). Of those 182 CWSs, 81 are suppliers and 101 are purchasers. Of the 81 suppliers, 74, 5, and 2 have surface water, blend, and ground water sources, respectively. Of the 81 suppliers, 33 are in Illinois, 16 are in Missouri, 12 are in Kansas, 12 are in Ohio, 4 are in Kentucky, 2 are in Indiana, and one each are in North Carolina and Texas (Table 4-2).

The highest atrazine concentration (42 ug/L) reported in the PLEX database from 1993 through 1998 is well below the Office of Drinking Water short term HALs for atrazine of 100 ug/L. However, because only one sample was collected per quarter/CWS in the PLEX database, reported maximum atrazine concentrations in the PLEX database may often be substantially less than actual peak concentrations. Because the VMS (on 100 surface water source CWSs) and the ARP surface water monitoring study (on 175 surface water source CWSs) have substantially more time series data than the PLEX database, observed maximum atrazine concentrations in those studies for a given CWS should generally be closer to actual peak atrazine concentrations

in the CWS than observed maximum atrazine concentrations for the same CWS in the PLEX database. However, the maximum reported atrazine concentrations in those studies (63.5 and 49.5 ug/L) were still well below the Office of Drinking Water short term HALs for atrazine of 100 ug/L.

10.2) Atrazine concentrations in the Rural Well Survey and comparison to Office of Drinking Water MCL and short term HALs for atrazine

In the Rural Well Survey from September 1992 to March 1995, one sample was collected from each of 1505 wells and analyzed for atrazine, and various chloro-triazine and hydroxytriazine degradates. The maximum, 99th percentile, and 95th percentile atrazine concentrations were 12.0, 2.4, and 0.87 ug/L.

Eight wells (out of the 1,505 wells sampled in the Rural Well Survey) had atrazine concentrations exceeding the MCL of 3 ug/L. Because only one sample was collected from each well, it is not known how many if any of those 8 wells had annual mean atrazine concentrations exceeding 3 ug/L. In the ARP ground water monitoring of 177 wells from May 1995 to March 1998, 2 of the 177 wells had a maximum annual mean atrazine concentration (14.3 and 4.97 ug/L based on running annual means) > 3 ug/L.

The highest atrazine concentration detected in the Rural Well Survey (12 ug/L) was much less than the short term HAL of 100 ug/L. However, because only one sample was collected per well in the Rural well Survey, the reported maximum atrazine concentration in the Rural Well Survey may be substantially less than the actual peak concentration. In the ARP ground water monitoring study of only 177 wells, but which included 12 samples/well/year over a 3 year period, one well had a maximum atrazine concentration (132 ug/L) greater than the short term HAL of 100 ug/L. However, the next highest atrazine concentration (11.0 ug/L) was well below the HAL.

10.3) Regression estimated, annual mean and annual maximum total chloro-triazine concentrations in the surface water portion of the PLEX database and comparison to HED sub-chronic/chronic and acute DWLOCs.

The regression estimated, highest annual mean total chloro-triazine concentration (17 ug/L) for surface water source CWSs in the PLEX database from 1993 through 1998 is slightly below the sub-chronic/chronic HED DWLOC of 18 ug/L for children and infants and well below the sub-chronic/chronic HED DWLOC of 63 ug/L for adults.

The assessed populations in the surface water portion of the Novartis PLEX database for 1998, 1997, 1996, 1995, 1994, and 1993 were approximately 44.0, 38.2, 41.5, 31.4, 24.0, and 23.9 million, respectively. The # of assessed surface water source CWSs in those years were 2494, 2132, 2547, 1699, 1700, and 1212, respectively.

The regression estimated, highest total chloro-triazine concentration (59.8 ug/L) for surface water source CWSs in the PLEX database from 1993 through 1998 is well below the single HED

acute DWLOC of 298 ug/L (for pregnant women).

In the PLEX database of atrazine data (collected to comply with the monitoring requirements of the SDWA), the annual maximum reported atrazine concentration for a CWS also represents its annual maximum reported 3-month quarterly mean because only one sample is generally collected per quarter (3 months). Therefore, the EFED compared regression estimated annual maximum total chloro-triazine concentrations to HED chronic as well as acute DWLOCs. The actual annual maximum quarterly mean for a CWS may be lower or higher than the annual maximum reported atrazine concentration for the CWS.

The population and the % of the assessed population exposed to estimated 1998, 1997, 1996, 1995, 1994, and 1993 annual maximum total chloro-triazine concentrations \geq the lowest HED sub-chronic/chronic DWLOC of 18 ug/L for children and infants were 1450 people (0.003%), 105,721 people (0.28%), 40,586 people (0.10%), 0 people (0.0%), 210,544 people (0.84%), and 184,092 people (0.77%), respectively. The assessed populations in the surface water portion of the Novartis PLEX database for 1998, 1997, 1996, 1995, 1994, and 1993 were approximately 44.0, 38.2, 41.5, 31.4, 24.0, and 23.9 million, respectively.

The # of CWSs and % of the assessed CWSs with 1998, 1997, 1996, 1995, 1994, and 1993 annual maximum total chloro-triazine concentrations \geq the lowest HED sub-chronic/chronic DWLOC of 18 ug/L for children and infants were 2 CWSs (0.08%), 9 CWSs (0.42%), 19 CWSs (0.75%), 0 CWSs (0.0%), 30 CWSs (1.77%), and 3 CWSs (0.25%), respectively. The # of assessed surface water source CWSs in those years were 2494, 2132, 2547, 1699, 1700, and 1212 CWSs, respectively.

The identities of, and populations served by CWSs with annual maximum total chloro-triazine concentrations \geq the HED sub-chronic/chronic DWLOC of 18 ug/L for children and infants can be obtained from the cumulative exceedence tables in Sub-Appendix A-5.

The regression estimated, highest annual maximum total chloro-triazine concentration (59.8 ug/L) for surface water source CWSs in the PLEX database from 1993 through 1998 was slightly below the HED sub-chronic/chronic DWLOC of 63 ug/L for adults.

10.4) Comparison of total chloro-triazine and total hydroxy-triazine concentrations in the Rural Well Survey to HED DWLOCs

One well (out of 1505 sampled in the Rural Well Survey) had a total chloro-triazine concentration equaling the HED sub-chronic/chronic DWLOC of 18 ug/L for the chronic exposure of children and infants, respectively. No wells had total chloro-triazine concentrations exceeding the HED sub-chronic/chronic DWLOC of 18 ug/L for children and infants, the HED sub-chronic/chronic DWLOC of 63 ug/L for adults or the single HED acute DWLOC of 298 ug/L for adult women.

The highest total hydroxy-triazine concentration detected (7.66 ug/L) was much less than the

lowest HED chronic DWLOC of 99 ug/L for children and infants.

Aquatic Exposure Assessment

Modeling Approach

For aquatic exposure assessment, the tier II refinement approach with PRZM (Pesticide Root Zone Model) and EXAMS (EXposure Analysis Modeling System) was simulated to generate the Estimated Environmental Concentrations (EEC's).

The environmental fate data for atrazine used in the tier 2 refined modeling are summarized in the following Table

Input Parameters for PRZM (version 3.12)

<u>Variable (units)</u>	<u>Variable Description</u>	<u>Input Value</u>	<u>Source of Info/Reference</u>
<u>DWRATE(1)¹</u> (day ⁻¹)	<u>Dissolved phase pesticide decay rate in surface horizon</u>	<u>DWRATE(1) = DSRATE(1)</u> <u>4.748 x 10⁻³</u>	<u>Aerobic soil metabolism study (GLN 162-1)</u> <u>140 and 146 days</u>
<u>DSRATE(1)¹</u> (day ⁻¹)	<u>Adsorbed phase pesticide decay rate in surface horizon</u>		
<u>DWRATE(2)</u> (day ⁻¹) <u>DWRATE(3)</u> (day ⁻¹)	<u>Dissolved phase pesticide decay rate in 1st, and 2nd subsurface horizon</u>	<u>DWRATE(2) = DSRATE(2)</u> <u>4.359 x 10⁻³</u> <u>DWRATE(3) = DSRATE(3)</u>	<u>Anaerobic soil/ anaerobic aquatic metabolism study (GLN 162-2/3)</u> <u>159 days</u>
<u>DSRATE(2)</u> (day ⁻¹) <u>DSRATE(3)</u> (day ⁻¹)	<u>Adsorbed phase pesticide decay rate in 1st and 2nd subsurface horizon</u>		
<u>KD(1)</u> <u>KD(2)</u> <u>KD(3)</u> (cm ³ gm ⁻¹ or mL g ⁻¹ or L kg ⁻¹)	<u>Pesticide partition or distribution coefficients for each horizon</u>	<u>use KOC value of 87.78 to estimate KD at each horizon</u>	<u>Mobility - Adsorption/Desorption study (GLN 163-1)</u> <u>average of 86.9, 38.5, 70.4, and 155.3</u>
<u>DEPI</u> (cm)	<u>Incorporation depth</u>	<u>Actual or pesticide label</u>	<u>Product label</u>

<u>TAPP</u> (kg ha ⁻¹)	<u>Application rate</u>	<u>Maximum label rate</u>	<u>Product label</u>
<u>APPEFF</u> (decimal)	<u>Application efficiency</u>	0.75 for aerial spray; 0.90 for ground spray.	<u>Product label;</u> <u>AGDRIFT²</u>
<u>DRFT</u>	<u>Spray drift fraction</u>	0.05 for aerial spray; 0.01 for ground spray.	<u>AGDRIFT²</u>

Input Parameters for EXAMS (Version 2.97.5)

<u>Variable</u> <u>(units)</u>	<u>Variable</u> <u>Description</u>	<u>Input Value</u>	<u>Source of</u> <u>Info/Reference</u>
<u>HENRY</u> (atm·m ³ ·mole ⁻¹)	<u>Henry's law</u> <u>constant</u>	<u>2.58 x 10⁻⁹</u>	-
<u>KBACW¹</u> (cfu/mL) ⁻¹ hour ⁻¹	<u>Bacterial</u> <u>biolysis in water</u> <u>column</u>	<u>9.89 x 10⁻⁵</u>	<u>twice of</u> <u>aerobic soil</u> <u>metabolism</u> <u>half-life</u> <u>(146 x2)</u>
<u>KBACS¹</u> (cfu/mL) ⁻¹ hour ⁻¹	<u>Bacterial</u> <u>biolysis in</u> <u>benthic sediment</u>	<u>4.75 x 10⁻⁵</u>	<u>608 days</u>
<u>KDP</u> (hour ⁻¹)	<u>Direct photolysis</u>	<u>1.72 x 10⁻⁴</u>	<u>335 days</u>
<u>KBH</u> (mole ⁻¹ hour ⁻¹) <u>KNH</u> (hour ⁻¹) <u>KAH</u> (mole ⁻¹ hour ⁻¹)	<u>Base hydrolysis</u> <u>Neutral</u> <u>hydrolysis</u> <u>Acid hydrolysis</u>	<u>0.0</u> <u>0.0</u> <u>0.0</u>	<u>Stable</u>
<u>KOC</u> (mL g ⁻¹ O.C.)	<u>Partition</u> <u>coefficient for</u> <u>organic carbon</u>	<u>87.78</u>	<u>average of</u> <u>86.9, 38.5,</u> <u>70.4, and 155.3</u>
<u>MWT</u> (g mole ⁻¹)	<u>Molecular</u> <u>weight</u>	<u>215.69</u>	
<u>SOL</u> (mg L ⁻¹)	<u>Aqueous</u> <u>solubility</u>	<u>33</u>	
<u>QUANT</u>	<u>Reaction</u> <u>quantum yield</u> <u>for direct</u> <u>hydrolysis</u>	<u>0</u>	
<u>VAPR</u> (torr)	<u>Vapor pressure</u>	<u>3 x 10⁻⁷</u>	

PRZM

PRZM (Version 3.12) relates pesticide movement to temporal variations of hydrology, agronomy, pesticide chemistry and meteorology. In order to run PRZM, four types of input data are needed: meteorology, soil, hydrology and pesticide chemistry. Except for the pesticide chemistry, the other three types of input data were adopted based on the standard scenarios established by the Water Quality Tech Team (WQTT) of EFED.

Based on the rainfall records and crop productions, the modeling scenarios chosen to represent the high runoff potential are listed below:

<u>Use Group</u>	<u>Site/Year</u>	<u>MLRA*</u>	<u>Soil</u>	<u>Hydrologic Soil</u>
Corn	Ohio (48' ~83') 111		Cardington Silt Loam	C
Sugarcane	Louisiana (64'~83')	131	Sharkey Clay	D
Sorghum	Kansas (48' ~ 83') 112		Dennis Silt Loam	C

*MLRA represents Major Land Resource Area, which are geographically associated land resource units (USDA, 1981).

The meteorology parameters including precipitation, evaporation and air temperature were obtained from ORD, Athens Laboratory. The soil properties including layer depth, soil texture class, soil composition (i.e., percentage sand, silt, clay, and organic matter), bulk density, field capacity, wilting point, and available water for each selected soil were extracted from PIRANHA databases.

EXAMS

The operation of EXAMS involved three types of data inputs: Environment, Load and Chemical. The standard Georgia farm pond data file was used to describe the Environment data input. The P2E-C1.D(X) [where "X" representing a two-digit number from 48 to 83, or 64 to 83], files generated by PRZM were used as the Load data input. The Chemical data input was created based on the E. Fate profile of atrazine.

EXAMS was run using data from 36 years using Mode 3 which used monthly environmental data and the daily pulse loads of runoff and spray drift. For each year simulated, the maximum annual peak, 96-hour average, 21-day average, 60-day average, 90-day average values, and the annual mean were extracted from the EXAMS output file REPORT.XMS with the TABLE20.EXE post-processor. The 10 year return EECs (or 10% yearly exceedance EECs) of corn, sugarcane, and sorghum listed in the Table below were calculated by linear interpolation between the third and fourth largest values by the program TABLE20.EXE.

Results - Aquatic EECs

The refined tier II approach with PRZM/EXAMS was implemented. The upper tenth percentile concentration values, expressed in ppb (ug/L), are summarized below. The results of three uses, corn, sugarcane, and sorghum, were based on the standard scenarios provided by the Water Quality Tech Team (WQTT) to predict reasonable high exposure values, i.e., soils with high runoff potential and heavy rainfall amounts.

Use	Peak	96-hr average	21-d average	60-d average	90-d average
Corn	38.24	38.02	37.18	35.50	34.16
Sugarcane	205.10	204.10	202.20	198.10	194.20
Sorghum	72.70	72.31	70.64	67.74	65.86

The modeling results indicate that atrazine does have the potential to move into surface waters, especially for sugarcane use.

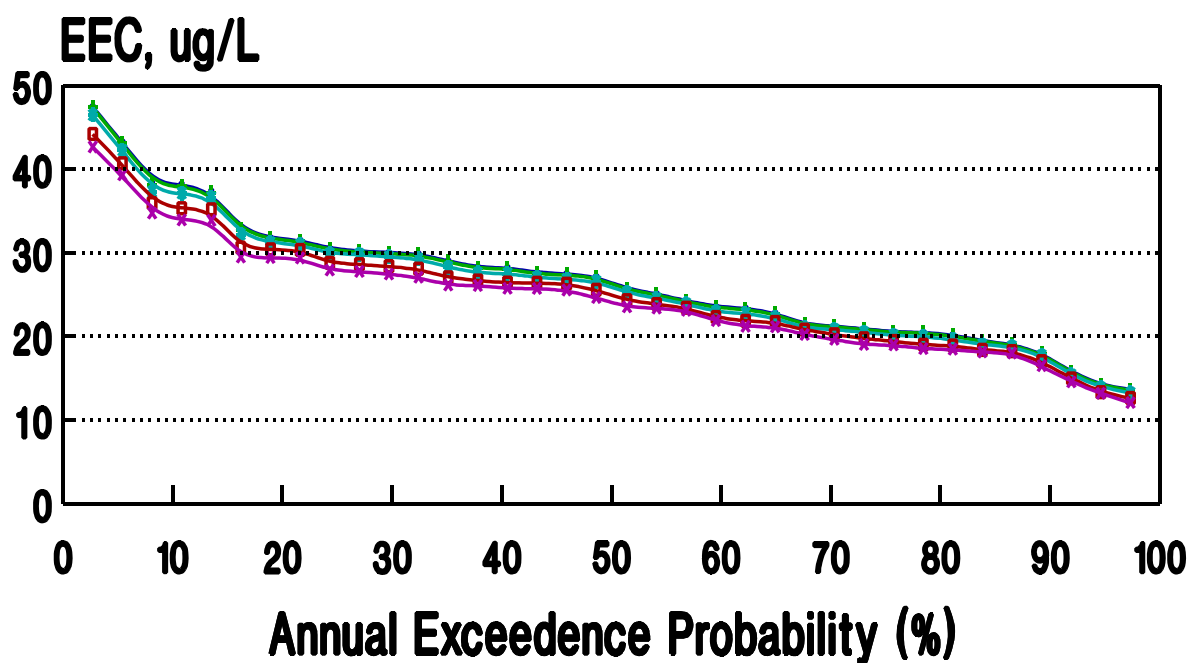
The post-processor, LOAD.EXE, was used to estimate the chemical contributions of runoff, erosion and spray drift to the standard farm pond. The results expressed as percentages are tabulated below:

Percent of Pesticide Loadings from Different Sources to the Standard Pond

Use	Runoff	Erosion	Spray Drift
Corn	55.03%	3.47%	41.50%
Sugarcane	99.15%	0.85%	0.01%
Sorghum	71.80%	5.29%	22.91%

The erosion losses were the smallest among the three components, except for sugarcane use scenario. Most of the atrazine losses to aquatic environments are from runoff.

EEC Plot - Atrazine Use on Corn
Major Land Resource Area (MLRA): 111
Indiana and Ohio Till Plain



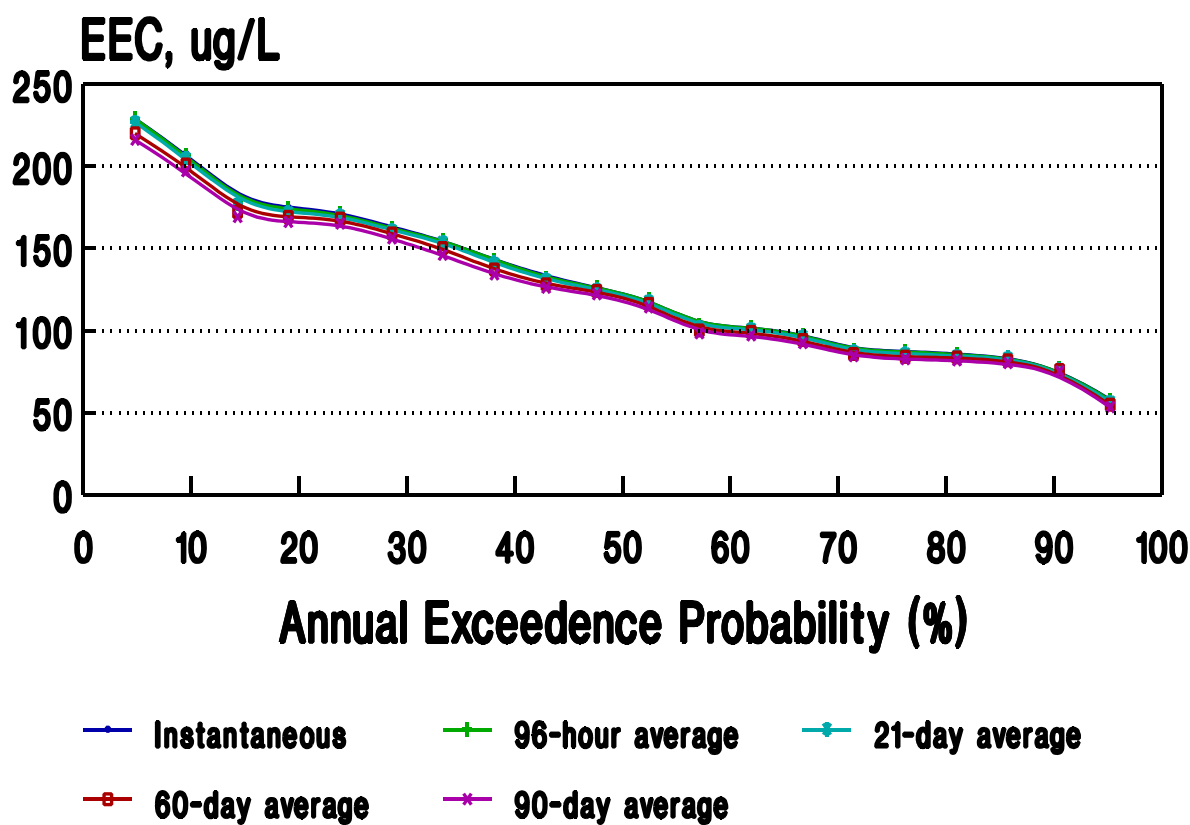
— Instantaneous — 96-hour average — 21-day average
 — 60-day average — 90-day average

Cardington Silt Loam (HSG: C)
Aerial Application
Preplant @ 2.0 lb a.i./ac

ATRAZINE USE ON CORN

<u>YEAR</u>	<u>WATER COLUMN DISSOLVED CONCENTRATION (PPB)</u>					
	<u>PEAK</u>	<u>96 HOUR</u>	<u>21 DAY</u>	<u>60 DAY</u>	<u>90 DAY</u>	<u>YEARLY</u>
1948	13.680	13.580	13.260	12.610	12.080	6.926
1949	14.140	14.060	13.880	13.320	13.190	10.440
1950	15.760	15.680	15.400	14.960	14.560	11.290
1951	23.380	23.250	22.760	21.830	21.200	15.030
1952	20.560	20.490	20.140	19.440	18.970	15.590
1953	29.880	29.730	29.300	28.060	27.050	19.430
1954	22.840	22.720	22.230	21.710	21.140	18.160
1955	19.090	19.010	18.790	18.220	18.000	15.290
1956	20.920	20.820	20.500	19.740	19.020	15.070
1957	32.860	32.720	32.200	30.610	29.410	20.940
1958	38.210	37.980	37.120	35.310	33.860	25.720
1959	37.370	37.200	36.610	35.180	33.910	27.120
1960	27.500	27.360	27.060	26.420	25.730	22.390
1961	27.630	27.470	26.840	25.580	24.640	20.060
1962	28.280	28.150	27.530	26.390	25.530	20.650
1963	25.710	25.580	25.240	24.330	23.520	19.600
1964	21.240	21.170	20.820	20.250	19.650	16.620
1965	20.510	20.420	19.980	19.010	18.450	14.920
1966	18.040	17.960	17.740	17.040	16.480	13.550
1967	30.050	29.900	29.490	28.380	27.460	18.950
1968	47.490	47.380	46.480	44.190	42.650	30.330
1969	43.270	43.080	42.260	40.680	39.310	32.090
1970	31.790	31.660	31.230	30.330	29.360	25.740
1971	28.230	28.100	27.580	26.680	26.080	21.600
1972	31.520	31.370	30.980	30.390	29.460	22.600
1973	25.110	25.010	24.570	23.860	23.370	20.090
1974	38.300	38.100	37.330	35.930	34.730	24.720
1975	27.160	27.040	26.580	26.280	25.750	22.750
1976	23.580	23.450	22.950	22.300	21.890	18.560
1977	19.460	19.380	19.020	18.390	18.120	15.750
1978	21.450	21.350	21.020	20.770	20.220	15.880
1979	20.200	20.090	19.640	18.900	18.530	15.320
1980	30.210	30.110	29.910	28.800	27.760	19.970
1981	30.530	30.360	29.820	28.610	27.920	22.190
1982	29.040	28.910	28.290	27.060	26.140	21.380
1983	24.270	24.140	23.910	23.410	23.120	19.420
Upper 10th Percentile	38.237	38.016	37.183	35.496	34.156	26.154

EEC Plot - Atrazine Use on Sugarcane Major Land Resource Area (MLRA): 131 Southern Mississippi Valley Alluvium



Sharkey Clay (HSG: D)
Aerial Application
preemergence @ 4.0 lb a.i./ac

MEAN OF ANNUAL VALUES =	19.337
STANDARD DEVIATION OF ANNUAL VALUES =	5.287
UPPER 90% CONFIDENCE LIMIT ON MEAN =	20.642

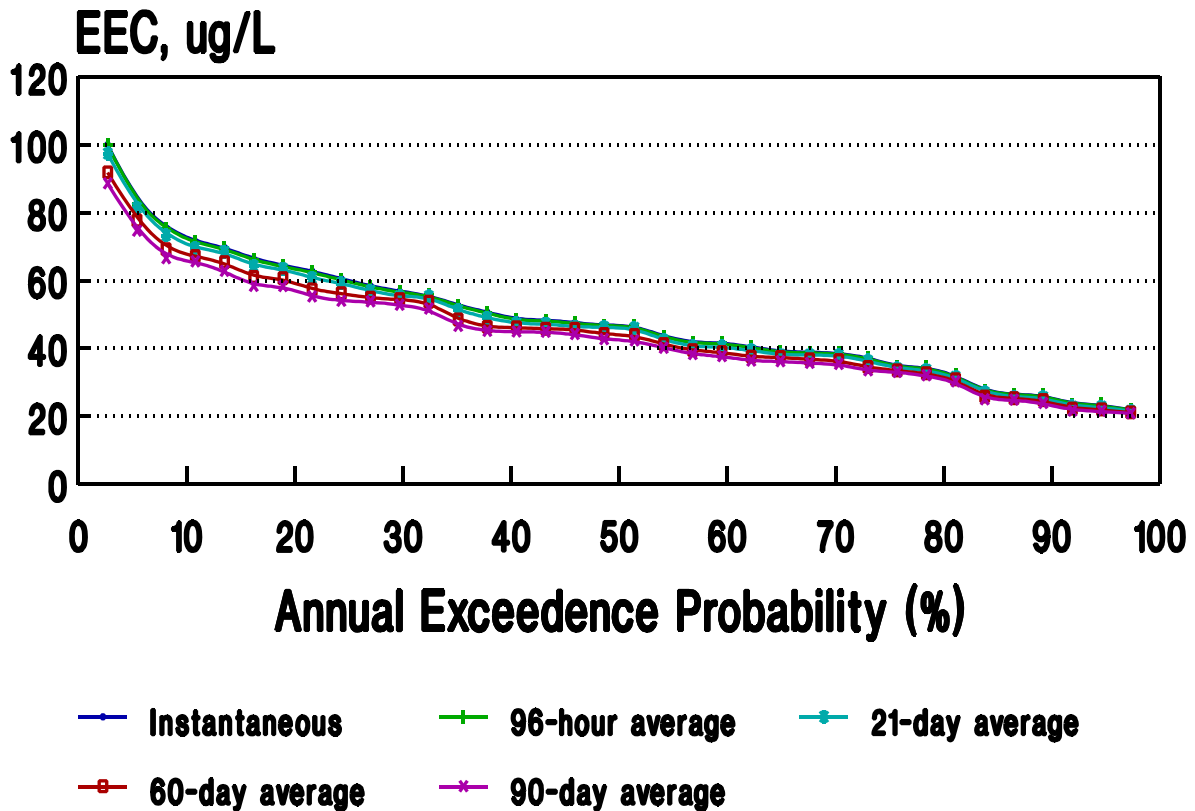
ATRAZINE USE ON SUGARCANE

<u>YEAR</u>	<u>WATER COLUMN DISSOLVED CONCENTRATION (PPB)</u>					
	<u>PEAK</u>	<u>96 HOUR</u>	<u>21 DAY</u>	<u>60 DAY</u>	<u>90 DAY</u>	<u>YEARLY</u>
1964	57.960	57.690	56.610	54.640	53.220	40.190
1965	87.580	87.270	86.000	83.530	81.670	63.870
1966	133.000	132.000	131.000	128.000	126.000	98.030
1967	103.000	103.000	102.000	99.860	98.170	79.370
1968	83.860	83.640	83.320	81.640	80.150	64.630
1969	119.000	119.000	118.000	116.000	114.000	88.150
1970	76.900	76.760	76.190	75.860	75.000	61.140
1971	85.600	85.320	84.500	83.870	82.530	64.820
1972	88.110	87.850	87.220	85.570	84.230	67.330
1973	97.760	97.450	96.430	94.080	92.280	72.340
1974	102.000	102.000	101.000	98.940	96.890	76.860
1975	143.000	143.000	141.000	137.000	134.000	105.000
1976	163.000	162.000	161.000	159.000	156.000	123.000
1977	175.000	174.000	172.000	169.000	166.000	131.000
1978	126.000	126.000	125.000	124.000	122.000	98.470
1979	155.000	155.000	154.000	150.000	146.000	115.000
1980	229.000	229.000	227.000	220.000	216.000	168.000
1981	208.000	207.000	205.000	201.000	197.000	157.000
1982	172.000	171.000	170.000	168.000	165.000	132.000
1983	179.000	178.000	177.000	172.000	169.000	134.000

Upper
10th Percentile 205.100 204.100 202.200 198.100 194.200 154.700

MEAN OF ANNUAL VALUES = 97.010
STANDARD DEVIATION OF ANNUAL VALUES = 35.121
UPPER 90% CONFIDENCE LIMIT ON MEAN = 108.774

**EEC Plot - Atrazine Use on Sorghum
Major Land Resource Area (MLRA): 112
Cherokee Prairies**



**Dennis Silt Loam (HSG: C)
Aerial Application
Preplant @ 2.0 lb a.i./ac**

ATRAZINE USE ON SORGHUM

WATER COLUMN DISSOLVED CONCENTRATION (PPB)						
<u>YEAR</u>	<u>PEAK</u>	<u>96 HOUR</u>	<u>21 DAY</u>	<u>60 DAY</u>	<u>90 DAY</u>	<u>YEARLY</u>
1948	50.720	50.410	49.010	46.270	44.190	21.970
1949	38.890	38.690	38.080	36.510	35.360	31.360
1950	32.120	31.940	31.560	30.860	30.210	26.320
1951	39.050	38.820	38.120	37.420	36.160	27.780
1952	66.370	65.950	64.290	60.950	58.370	39.860
1953	48.530	48.280	47.310	46.190	44.890	40.210
1954	34.520	34.350	34.090	33.460	33.020	29.870
1955	26.390	26.240	25.620	25.270	24.940	22.820
1956	23.430	23.310	22.760	22.200	21.590	19.080
1957	27.430	27.270	27.000	25.740	24.820	19.470
1958	23.490	23.370	22.830	21.960	21.510	18.600
1959	21.910	21.780	21.530	21.120	20.830	17.390
1960	26.250	26.140	25.560	24.690	23.900	18.820
1961	41.740	41.490	40.480	39.400	38.310	27.360
1962	64.500	64.110	63.410	60.600	58.330	41.460
1963	62.780	62.390	60.740	57.330	55.260	45.510
1964	48.410	48.170	47.260	45.690	44.840	41.030
1965	38.640	38.440	37.980	36.700	35.710	31.830
1966	40.540	40.310	39.390	37.540	36.360	29.680
1967	43.540	43.290	42.440	41.200	40.160	31.790
1968	37.350	37.160	36.290	34.420	33.420	29.770
1969	41.670	41.430	40.520	38.860	37.650	29.820
1970	60.560	60.200	59.150	56.200	53.950	38.740
1971	46.830	46.590	45.990	44.210	42.660	37.700
1972	34.560	34.360	33.620	32.650	32.020	29.550
1973	58.390	58.050	56.980	54.830	52.810	37.050
1974	100.000	99.840	97.310	91.840	88.580	60.470
1975	82.780	82.440	81.330	77.590	74.640	64.500
1976	55.640	55.560	55.250	54.460	53.760	47.640
1977	52.650	52.410	51.200	48.460	46.600	39.210
1978	47.580	47.330	46.240	43.870	42.320	36.220
1979	56.810	56.490	55.300	53.680	51.700	39.190
1980	75.400	75.050	73.280	69.150	66.500	48.800
1981	71.540	71.140	69.510	67.140	65.590	54.300
1982	69.750	69.380	68.410	65.320	62.780	52.210
1983	46.710	46.650	46.380	45.720	45.120	39.610

Upper
10th 72.698 72.313 70.641 67.743 65.863 52.837
Percentile

MEAN OF ANNUAL VALUES = 35.194
STANDARD DEVIATION OF ANNUAL VALUES = 11.797
UPPER 90% CONFIDENCE LIMIT ON MEAN = 38.105

USGS 1992-1993 Study of 76 Mid-Western Reservoirs (USGS Open-File Report 96-393):

The USGS sampled the outflows from 76 mid-western reservoirs 8 times (approximately once every two months) from April 1992 through September 1993 (USGS Open-File Report 96-393). The samples were analyzed for a number of pesticides and pesticide degradates including atrazine, de-ethyl atrazine (DEA), and de-isopropyl atrazine (DIA). The reservoirs were selected from a list of approximately 440 reservoirs in 11 mid-western states. The locations of the reservoirs are shown below. Information about the sampled reservoirs is supplied in table.

The sampling frequency was inadequate for EFED to provide an atrazine, time series for the reservoirs. However, EFED generated 1992 and 1993 cumulative exceedence curves of maximum annual atrazine, DEA, and DIA concentrations versus the % of reservoirs with equal or greater annual maximum concentrations.

Fig. VI-2 USGS 1992 Lake Reservoir
Misc. maxima cumul. exceed. curves

